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Adapter

Field of the Invention

The present invention relates to devices for administration by injection or infusion of liquid compositions for diagnostic or therapeutic purposes. More particularly the present invention is directed to an adapter for a power injector used to dispense the contents of a cartridge or dispense cartridge.

Description of related art

In a number of medical procedures, it is desirable to inject a multi-component medium to a patient. An example of such a medical procedure is ultrasound imaging. For ultrasound imaging the most common contrast media comprises microbubbles dispersed in an aqueous carrier. A problem with the continuous infusion of gas-containing diagnostic contrast agents arises from the tendency of gas-containing components such as microbubbles to float, since this will lead to inhomogeneities forming within vessels such as power-driven cartridges which may be used to administer the contrast agent. This may, for example, lead to an increase in microbubble concentration in the upper part of such a vessel and/or to changes in size distribution occurring at various points within the vessel as larger microbubbles float more rapidly than smaller microbubbles.

Power injectors for controllably delivering diagnostic and therapeutic compositions are well known. Typically such apparatus include an automatic power injector for coupling to a cartridge or syringe containing an injectable liquid. Such cartridge further has a plunger or piston movable within the barrel of the cartridge to expel the liquid through a tip thereof. The automatic power injector typically has a syringe- or cartridge-receiving unit, adapted to hold the cartridge, and an electromechanical arrangement organized to push the plunger of the cartridge at a desired rate. The mode and rate of injection or infusion is hence accurately controlled. Compared to hand injection, automatic power injectors have the benefit of maintaining a consistent flow over a long time, thereby providing a consistent amount of the injectable composition, such as a contrast media, in the blood stream.

The available automatic power injectors on the market have, however, no control of the homogeneity of the injectable formulation stored in the cartridge barrel during the course of administration. When the injectable formulation is a dispersion of particles that tend to settle, float, coalesce or segregate, such as e.g. an ultrasound contrast agent, it is desirable to keep the contents of the cartridge homogeneous during administration. As automatic power injectors are frequently used in infusion or injections, and as such equipment being available in most hospitals, it is also desirable to enable use of such

injectors for administration of a formulation wherein preservation of homogeneity is needed. The present method and devices give an effective solution to this problem.

Some methods and devices for maintaining a homogeneous solution during administration have been described earlier. WO 99/27981 of Bracco Research S.A. describes an automatic liquid injection system and a method for its use. The injector system includes a cartridge containing a dispersion and this dispersion is subjected to a rotation or rocking motion in order to maintain a homogeneous dispersion. This patent application further describes an injector system comprising a cartridge, automatic electromechanical power means, and means for agitating a dispersion in the cartridge, such as e.g. a set of rollers. The injector system includes an injector pump suited for rotation of an integrated cartridge.

WO 00/53242 of Medrad Inc. describes devices, systems and methods for dispensing a multi-component medium. A system described comprises a container to hold the medium, a pressurizing device, such as a pump, and an agitation mechanism or device to maintain the components of the medium in a mixed state. A long list of ways of achieving agitation is included. Rotation of a storage volume, such as a cartridge, is one of the described ways of achieving agitation of a multi-component medium.

WO 00/12157 and WO 00/12158 both of Schering AG describe syringes and injectors incorporating an agitation device, such as a ball, respectively a magnetic agitation device and a mechanical agitation device. WO 00/12158 further describes that the system can include accessories encompassing devices physically connected to an injector and assume the role of moving the entire injector or parts thereof in such a way that the syringe changes position. Examples of such accessories are a table for the injector executing a wobbling movement and a motor-drive shaft.

Each of the above-described systems therefore provide an agitation means integrated into the dispenser. There is still a need in the art, however, for providing an agitation capability to a linear-stroke automatic power injector both before and during administration of the fluid contents.

Summary of the invention

In view of the needs of the art the present invention provides a cartridge adapter connectable with an automatic power injector and a syringe or cartridge containing contents to be dispensed. The adapter comprises means for agitating the content of the cartridge. The cartridge adapter includes an adapter body receivable by the power injector, a cartridge retainer for retaining the cartridge, and a cartridge driver for agitating the contents of the cartridge.

Furthermore, the present invention provides devices, apparatus and methods for delivery of a composition, such as an ultrasound contrast agent, to a patient. Particularly the invention provides methods and devices for securing homogeneity of the composition during administration, such as during an infusion procedure. The invention gives a method and means whereby the composition is kept under sufficient agitation so as particles in the composition do not settle, segregate, float or agglomerate undesirably. Such an apparatus includes generally a cartridge or syringe to hold the composition, an automatic power injector and a mixing device for maintaining the components of the composition in a mixed state.

In the present invention the mixing device is an adapter which receives a syringe, or cartridge. The adapter itself is received by an automatic power injector. The adapter of the present invention is suitable for use with available marketed injectors and with conventional cartridges so as to preserve the homogeneity of the composition to be administered. The great advantage of the adapter of the invention is that this allows for use of standard power injectors and will be easy to use and validate.

By connecting the adapter to an injector and a cartridge, rotation of the cartridge is achieved and the composition in the cartridge is sufficiently agitated to keep the components of the composition in a mixed state during administration. Mechanical agitation is provided to the extent that is sufficient to keep the composition homogeneous but insufficient to break or damage the particles in the composition. The cartridge barrel is subjected to a rotational motion, continuous or discontinuous, optionally alternating the rotation direction and desirably the speed of the rotation.

The adapter of the invention has at least partly the same geometry as a standard cartridge so as to be compatible with a cartridge-receiving-unit of an automatic injector. The adapter further provides means for rotating the cartridge, such as a motor, batteries, a cartridge retainer and operator buttons.

Brief description of the drawings

Figure 1 illustrates an automatic power injector of the prior art.

Figure 2a illustrates a first adapter according to the present invention.

Figure 2b illustrates the adapter of figure 2a further indicating the cartridge driver.

Figure 3 illustrates the adapter of Figure 2 placed in the automatic power injector of Figure 1.

Figures 4 and 5 illustrate the adapter of Figure 2 placed in an automatic power injector and how to connect the adapter to a cartridge.

Figure 6 illustrates the operation of an apparatus comprising an injector, a cartridge and an adapter of Figure 2.

Figure 7 illustrates a second embodiment of an adapter according to the present invention.

Figure 8 illustrates a third embodiment of an adapter according to the present invention.

Figure 9 illustrates the adapter of Figure 8 placed in an injector of Figure 1 and connected to a cartridge.

Detailed description of the invention

One embodiment of the present invention is an adapter for connection with an automatic power injector and/or a cartridge or syringe. The adapter is detachably connectable to standard injectors and cartridges. That is, the adapter can be connected, joined, linked, fastened or coupled to, and de-touched from, an automatic power injector and/or a cartridge. The adapter further comprises means for agitating the cartridge by rotational movements.

There are many injectors currently installed in the hospitals worldwide. Briefly stated, such injectors generally comprise a cartridge receiving-unit, a dispense shaft or drive head, a motor and electronics to drive the dispense shaft controllably against a syringe plunger or piston, and a control keyboard. Many injectors also have a size-reading unit. When placing a cartridge in the cartridge receiving-unit of the injector this size-reading unit registers the diameter of the cartridge placed in the injector. Based on this size-reading the cartridge dimensions are calculated giving the correct injection rate when set to operate. The injectors are designed to comply with standard cartridge sizes.

To ensure compatibility with existing injectors the adapter of the invention includes a portion having the same or similar geometry as a cartridge. The adapter is designed to have partly the same geometry as a cartridge in order to comply with the cartridge receiving-unit, e.g. a cartridge cradle, of the injector. Desirably the adapter also has geometry complying with any size-reading-unit of the injector. When placing the adapter in the cartridge-receiving-unit of the injector and the cartridge size-reading-unit is closed the injector will select the correct cartridge size, based on the reading of the adapter dimensions, and thereby giving the correct injection rates when set to operate.

To ensure such compliance the adapter desirably comprises an at least partly elongated cylindrically shaped body or housing. Desirably, this body should have a circular cross-section, resembling the barrel of a cartridge. Most desirably, to ensure maximum compatibility with existing injectors used in hospitals the adapter has at least partly the same shape and size as a 50-ml cartridge. When the adapter is placed in an injector, the injector therefore "believes" a cartridge has been placed in the injector, and it calculates

the right rate of administration, based on the dimensions of the adapter. A size readable-unit of the adapter is designed to comply with any size-reading-unit of the injector. This unit desirably has substantially the same cross-section as the barrel of the cartridge to be used. Most desirably the size-readable unit of the adapter has the diameter as the barrel of a 20-ml or 10-ml cartridge.

The adapter at least comprises an adapter body, a cartridge retainer, and a cartridge driver for agitating the injectable contents of the cartridge.

The adapter body preferably has an elongate shape and is receivable by the power injector. The adapter body further includes means for providing rotation of the cartridge retainer. These means for rotation would for instance comprise a motor, electronics, and converters. Batteries are included if needed. Rotation can be achieved e.g. with a belt or wheel actuated by a motor of some kind. The motor is desirably integrated inside the adapter body. Optionally, any size-readable unit can either be integrated as part of the adapter housing or could be a separate unit connected with the housing.

The cartridge retainer of the adapter is designed to hold and rotate the cartridge. Energy is transferred from the motor in the adapter body to the cartridge retainer and motor driven rotation of the cartridge is enabled. There may hence be a torsion energy transfer from the motor to the cartridge retainer. The rotational part of the holder may comprise a swivel connector, a ball-bearing low friction arrangement that allows rotating while being fixed, holding means such as jaws or a clamp. The cartridge retainer comprises both holding and rotational means. The cartridge retainer preferably includes an insertion aperture, through which a cartridge may be threaded. The retainer should then comprise a cartridge ring which further comprises cartridge retaining means extending about the insertion aperture for engaging and retaining the cartridge. Moreover, the cartridge retainer is designed to accommodate the flanges of a cartridge to form a lockable rotateable holder. A cartridge may then be inserted by threading it through the insertion aperture of the adapter, rotating the cartridge 90 degrees and reversing the direction of insertion. The flanges of the cartridge will then engage the rotating part of the adapter.

The cartridge driver means enables agitation of the content of the cartridge. The cartridge driver preferably comprises a motor and drive means, preferably positioned within the adapter body as described above. More preferably the drive means further comprises a drive belt engaging a moving portion of the motor and the cartridge retainer, such as the cartridge ring of. The cartridge driver causes the cartridge ring to reciprocally rotate about the insertion aperture.

A plunger-pressure-unit of the adapter is designed to transfer the injection movement from the drive head of the injector to the plunger of a cartridge held by the cartridge retainer. The dispense shaft of the injector can hence act on this plunger-pressure-unit, to effect movement of the injector to the cartridge plunger. The plunger-pressure-unit hence acts as an extension to the drive head. The plunger-pressure-unit may simply consist of a guide piston. The drive head of the injector may hence act directly on this guide piston transferring movement from the injector to a cartridge plunger. The adapter body then defines a guide piston opening and an elongate guide piston passageway in fluid communication with the guided piston opening for slidably receiving the guide piston between a first and second position. However, the geometry and dimensions of some drive heads may be sufficient to directly act upon a plunger of the cartridge held by an adapter of the present invention, making such plunger-pressure-unit redundant. Alternatively, the plunger-pressure-unit may comprise an extension arm in addition to the guide piston. The extension arm preferably includes a free end in movable spaced registry with the cartridge retainer. Preferably, the extension arm is pivotally mounted to the guide piston. Further, the extension arm may support a dispense rod for engaging the cartridge plunger. Ideally, the dispense rod should be able to either rotate freely or with as little friction as possible with the cartridge plunger. Preferably, the guide piston is adopted to move slidably, with as little friction as possible.

The different parts of the adapter may be arranged in alternative ways. The adapter housing, the cartridge retainer, and the guide piston may all be positioned substantially in-line. When in-line, desirably the adapter is shaped as a cartridge having a substantially elongate cylindrically shaped housing, a guide piston extending from one end of the housing, going generally through the cylindrical housing, and a cartridge holder, or a cartridge retainer, forming the other end of the cylindrical. A cartridge can hence be mounted to one end of the elongate body. When placing a cartridge in the holder the cylindrical housing, the guide piston and the cartridge will be positioned substantially in-line. Alternatively, the adapter is designed such that the cartridge retainer holds the cartridge substantially in parallel with the cylindrical housing. Preferably, the cartridge container is offset from the adapter body.

A cartridge placed in the adapter is subjected to a rotational agitation. Generally, when a cartridge containing a stationary fluid is rotated a certain angle around its central longitudinal axis, the fluid volume inside is displaced in a predictable manner. When the motion is reversed by moving the cylinder back to its original angular position, the fluid will eventually also move back again to exactly its original position, and sufficient agitation has not been achieved. The adapter of the invention desirably imparts a rotation with respect to the longitudinal axis of the cartridge. The movement may be continuous or discontinuous. However, the adapter desirably subjects the cartridge to an oscillating

rotation making an asymmetric pattern. The oscillating rotation may be performed by alternately rotating the cartridge at a certain angle in one direction and then reciprocally in the opposite direction so as to prevent a harmonic oscillation of the dispensable fluid. Alternatively, the cartridge may be rotated at different angles in the opposite directions. The most preferable way of achieving an asymmetric rotation is by alternately rotate the cartridge in opposite directions, around its longitudinal central axis, wherein the speed of rotation differs in the two directions. Alternatively, asymmetric rotation may be achieved by rotating at set angles but at varying speed of rotation. If the angular speed of rotation is different when the reverse rotation is performed, there will be a small net displacement of the fluid when returning to the original position. This is caused by non-linearities in the viscous behavior of the fluid, and possibly also turbulence if the angular acceleration is high enough. An oscillating rotational shaking of a cartridge in this manner will hence cause a long-term net rotation of the fluid inside the cartridge. A short angle back-and-forth rotational shaking has a substantial advantage, since any tubing from the cartridge to the patient will not become twisted. Although the angular excursions might be quite small, there will be a complete shaking, since a continuous circulation flow pattern is generated in the cartridge.

Figure 1 illustrates an automatic power injector 1 of the prior art. Similar injectors are available on the market, such as for instance a Fresenius DPSIS. A cartridge with a composition for delivery may be connected to or placed in the injector, and the injector enables controllable delivery of the compositions to a patient. An adapter of the invention may be used with such injector. The injector of Figure 1 has an injector housing 2. The injector further has a cartridge-receiving-unit 3. This unit is designed to receive a cartridge, and will typically have a substantially half-cylindrical shape, forming a cradle 3a. In combination with the cartridge-receiving-unit 3 there is a cartridge size-reading-unit 4. When placing a cartridge in the cartridge receiving-unit 3 this part of the injector reads the size of the cartridge installed, usually based on the diameter of the cartridge. The size-reading-unit 4 will typically comprise a clasp 4a that can pivot between an opened position allowing access to cradle 3a and a closed position in spaced registry with cradle 3a so as to retain a cartridge therein. The injector further comprises a elongate longitudinally-displaceable dispense shaft 5. When placing a cartridge in the injector the dispense shaft 5 engages and moves the plunger rod of the cartridge. The housing 2 includes electromechanical arrangement enabling a driving of the dispense arm 5 of the injector towards the cartridge at a desired rate so as to provide controlled dispensement of the contents of the cartridge. The dispense arm 5 supports an injector drive head 6 at one end which itself may support drive release and anti-siphon controls 6a. Drive head 6 engages the piston shaft of a common cartridge or dispense cartridge positioned in cradle 3a so as to cause the contents of the cartridge to dispense as dispense arm 5 carries

drive head 6 towards the cartridge. The injector should further have a control panel 7 for assisting an operator.

Figure 2a illustrates a first example of an adapter 9 according to the present invention. The adapter 9 is compatible with the injector 1 of figure 1. The adapter 9 includes an elongate adapter body, or housing, 10 having geometry complying with the cartridge receiving-unit 3 of the injector 1 in figure 1. Adapter 9 also includes a cartridge retainer 12 for retentatively engaging a cartridge having contents to be dispensed. A cartridge driver mechanism is also provided, described hereinbelow, for agitating the contents of the cartridge. Housing 10 is typically formed of a suitably rigid plastic material and desirably includes a substantially elongated cylindrical portion 40, resembling the barrel of a cartridge. Housing 10 includes a size readable-unit 11 designed to fit within the size-reading-unit 4 of the injector 1. Size readable-unit 11 comprises a neck 42 and an annular shoulder 44 which simulate the size and shape of the base end of a cartridge or dispense cartridge.

Adapter 9 further includes a cartridge retainer 12 at a free end of a holding arm 13 extending substantially transversely to housing 10. Cartridge retainer 12 defines an annular track within which a cartridge ring 14 may rotate. A cartridge may be positioned in cartridge retainer 12 and rotated with cartridge ring 14, as shown in Figure 4. Cartridge ring 14 defines an insertion aperture 50 into which a cartridge having contents to be dispensed may be inserted and retained. Cartridge ring 14 desirably includes a number of retaining arms 52 extending towards insertion aperture 50 for retentatively engaging an inserted cartridge. With additional reference to Figure 3, retaining arms 52 define opposed first and second open notches 53 and 55 for allowing the flanges of a cartridge to pass therethrough. Retaining arms 52 further define therebetween opposed first and second closed flange-receiving notches 54 and 56 into which the flanges of a cartridge may be retentatively engaged.

Annular shoulder 44 defines a guide opening 46 in fluid communication with a guide piston passageway 48 defined by housing 10. Passageway 48 slidably accommodates a guide piston 16 therein. A free end of guide piston 16 supports an extension arm 15 which engages the drive head 6 of power injector 1. Extension arm 15 extends substantially transversely to guide piston 16 and desirably supports a dispense rod 17 at a free end 15a in spaced registry with insertion aperture 50. Dispense rod 17 may be rotationally supported on extension arm 15 by an axle 18. Alternatively, dispense rod may be fixed with respect to extension arm 15. Movement of extension arm 15 and guide piston 16 is further illustrated in Figure 5.

The Adapter 9 further includes means for imparting rotational energy to the cartridge ring 14, as shown by phantom lines in Figure 2b. Adapter 9 includes an electric motor 56 which rotates a drive shaft 58. One free end of drive shaft supports a drive belt 60. Drive belt 60 extends through an open interior portion of holder 19 and in annular track 49 about cartridge ring 14. Motor 56 may rotate continuously in a single direction as well as in a reciprocating motion so as to causes a cartridge held by cartridge retainer 12 to be agitated, thereby preserving the homogeneity of the contents of the cartridge. Motor 56 desirably urges cartridge ring 14 to reciprocatingly rotate through about ninety degree arcs so as to impart a reciprocating rotation of the inserted cartridge. Motion of motor 56 is desirably directed by controller circuitry 62 which operates according to operator selected inputs at control panel 64. Control panel 64 desirably provides an operator to, at a minimum, select a pre-programmed routine for rotation of cartridge ring 14, such as the speed, direction, and amount of rotation. On-off controls allow the operator to commence and terminate agitation of the inserted cartridge.

Figure 3 illustrates the adapter 9 of Figure 2 placed in the automatic power injector 1 of Figure 1. Cylindrical portion 40 of housing 10 of the adapter is positioned in cradle 3a of cartridge receiving-unit 3. Extension arm 15 and dispense rod 17 are shown positioned towards the insertion aperture 50 of adapter 9. When having positioned the adapter 9 in the cartridge receiving-unit 3, the clasp 4a of size-reading-unit 4 is in the closed position about neck 42 of size readable unit 11. The injector may correlate the outer dimensions of neck 42 with a stored software program, thereby giving the correct injection rates when set to operate.

Figure 4 illustrates the adapter 9 positioned in an injector 1 while also accommodating a cartridge 20. Cartridge 20 is a typical cartridge, or dispense cartridge, as known in the art and includes an elongate barrel 21, flanges 22 transversely-extending from a base of barrel 21, a plunger 23, and a plunger rod 24. Cartridge 20 is optionally connected to a tubing 25 at the cartridge nozzle 26. The filled cartridge 20 is inserted, plunger end first (as shown by arrow A), through insertion aperture 50 of cartridge ring 14 desirably. The cartridge ring 14 of cartridge holder defines a pattern complying with the flanges 22 of the cartridge to allow the flanges to clear through aperture 50. After having inserted cartridge 20 through cartridge ring 14, the cartridge 20 is rotated 90 degrees (depicted by arrow B) and the direction of insertion is reversed (depicted by arrow C) to retain cartridge 20 within cartridge ring 14. The flanges 22 of the cartridge will engage with the retaining arms 52 of cartridge ring 14 thereby locking cartridge 20 in the cartridge retainer 12. Cartridge 20 now extends generally in parallel to adapter housing 10.

Figure 5 further illustrates the cooperation between drive head 6, extension arm 15, and cartridge plunger rod 24 so as to dispense the contents of cartridge 20. The dispense rod

17 of extension arm 15 may be manually positioned in abutting engagement with the free end of plunger rod 24 of cartridge 20. Injector drive head 6 is moved into abutting engagement with extension arm 15. The entire dispense apparatus, comprising injector 1, cartridge 20, and adapter 9 is now ready for operation, as is illustrated in Figure 6. Movement of drive head 6 urges extension arm 15 and, hence, plunger rod 24 in a dispensing direction which discharges the contents of cartridge 20 through nozzle 26. Injector 1 may be set to run with injection rates as per instructions for the product to be injected or infused. As injector 1 cannot distinguish between adapter 9 and cartridge 20, all features, such as alarms, occlusion stop etc. in the injector will still be active. During injection cartridge 20 will have the set longitudinal dispense rate (denoted by arrows D, E, and F) ensured by the injector 1, while the optimum sequence of alternating rotation (denoted by arrow G) of the cartridge 20 is ensured by adapter 9.

Figure 7 illustrates a second alternative of an adapter 30 according to the invention connected to a cartridge 20. This adapter 30 has the same main parts as the adapter 9 of Figure 2, with like numerals denoting like components; a housing 110, a cartridge size readable-unit 111, an extension arm 115 and a cartridge retainer 112. In this alternative, however, cartridge size readable-unit 111 forms an integrated part of the housing 110. Desirably, cartridge size readable-unit 111 includes a substantially circular cross-section but it may include a substantially planar portion 111a so as to provide an outer dimension shaped to mimic the dimensions of a particular-sized cartridge to the size-reading-unit 4 of injector 1. Further, cartridge retainer 112 is directly mounted to housing 110, without an extending holder arm. The extension arm 115 is supported by elongate guide piston 116 and supports dispense rod 117. Member 117 is an elongate member especially suited for dispensing the contents from dispense cartridges which, while including a slidable piston, lack a plunger rod. Member 117 thereby acts as the plunger rod to move the slidable piston. Dispense rod 117 further supports a swivel 131 at a free end thereof in spaced registry with insertion aperture 150. Swivel 131 allows the plunger rod 24 of a cartridge 20 to more freely rotate with cartridge barrel 21. The present invention contemplates that extension arm 115 may be pivotally mounted at an axle 161 so as allow dispense rod to be movable about arrow H between opposed positions in and out of registry with insertion aperture 150. Axle 161 thereby allows a cartridge to be loaded through insertion aperture 150 nozzle end first.

An electric motor 156 is shown in phantom lines having an elongate rotating shaft 158 in driving engagement of a cartridge ring 114. Cartridge ring 114 rotates within an annular track 149 defined by cartridge retainer 112. The present invention contemplates that shaft 158 and cartridge ring 114 may each include gear teeth to enhance driving engagement therebetween.

Figures 8 and 9 illustrate another adapter 35 of the present invention; with like numerals denoting like components to the hereinabove described embodiments. Adapter 35 is shown connected to a cartridge 20. The adapter 35 comprises an elongate substantially cylindrical housing 210, a size readable-unit 211 by which adapter 35 is retained by an injector 1, an elongate guide piston 216 and a cartridge retainer 212. The clasp 4a of the size-reading-unit 4 of an injector is further shown in Figure 8 engaging size readable unit 211. Cartridge 20 is positioned by adapter 35 to be substantially in-line with housing 210. The housing 210 generally resembles a cartridge barrel having a substantially cylindrical shape.

The Adapter 35 should also include a cartridge driver, or rotational means, such as a motor, drive shaft and the necessary electronic control circuitry.

Adapter 35 further includes an elongate guide piston 216 which is longitudinally movable under the urging of drive head 6 of Injector 1. Size readable-unit 211 defines a guide opening 246 for receiving guide piston 216. Housing 210 further defines an elongate guide piston passageway 248 for accommodating guide piston 216 therethrough. Guide piston 216 supports a cartridge plunger engagement member 215 at first end 216. The cartridge plunger engagement member 215, is therefore able to urge the cartridge plunger rod of cartridge 20 towards nozzle 26 and thereby provide for dispensement of the cartridge contents.

Figure 9 illustrates an apparatus comprising the adapter 35 of Figure 8 loaded in injector 1 and connected to a cartridge 20. When adapter 35 is positioned in the cartridge-receiving-unit 3 of the injector 1, clasp 4a of cartridge-size-reading unit 4 is closed, thereby holding adapter 35 by the cartridge-size-readable-unit 211. When having connected a cartridge 20 to the cartridge retainer 212 and the injector drive head 6 attaches the guide piston 216 the apparatus is ready for operation. Rate and mode of injection will be ensured by the injector, pushing the guide piston 216 at a desired rate, while the desired rotational agitation is ensured by the adapter 35.

Yet another embodiment of the invention is a power injection apparatus employing an adapter of the present invention. Such apparatus may be used for administration of a liquid composition and comprises an automatic power injector and adapter of the invention, and optionally a cartridge. Desirably, such apparatus is used for injection or infusion of a dispersion of microparticles homogeneously distributed in a carrier liquid. The adapter includes means for rotating the cartridge to obtain a uniform distribution of the liquid composition in the cartridge. The apparatus may further comprise a tubing connected to the cartridge nozzle for transferring the composition to a patient. Optionally the apparatus may comprise means for admixture of the composition of the cartridge with

a flushing medium prior to administration to a subject. Such means may simply comprise a three-way connector, e.g. a T-piece, a Y-piece or a tap such as a three way stopcock connected to a tubing from the cartridge and a flushing medium reservoir.

Yet another embodiment of the invention is use of the adapter and the apparatus as herein described. Accordingly, a method of administering a liquid composition using such apparatus is encompassed. Desirably, a method of administering is by injection or infusion of a dispersion of microparticles homogeneously distributed in a liquid carrier by an apparatus comprising an injector, a cartridge comprising the dispersion and an adapter, wherein the adapter comprises means for rotating the cartridge to obtain a uniform distribution in said cartridge.

The adapter, method and apparatus of the invention may be used for administration of different liquid compositions to patients, human beings or animals. The compositions may be for therapeutic or diagnostic purposes. The apparatus may be used for administration of any composition comprising multi-component fluids wherein the components are not totally miscible and there is a tendency for the components to separate over time. Such composition may comprise particles that tend to settle, float, coalesce or segregate. The apparatus and method of the invention is particularly useful for administration, such as infusion, of dynamic (i.e. gravity segregating) particulate dispersion systems, e.g. gas-containing diagnostic contrast agents. Examples of such ultrasound contrast agents are, for purposes of illustration and not of limitation, Levovist, Albunex, Optison, Definity, Imagent, Sonovue, Echogen, Sonogen and Sonazoid.

While the present invention has been discussed in connection with the delivery of a therapeutic or diagnostic liquid composition, other uses of the invention exist. The agitation mechanism provided by the adapter is also suitable for use in non-medical applications wherein mixing is desirable, such as e.g. in chemical synthesis.

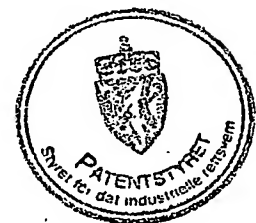
While the preferred embodiment of the present invention has been shown and described, it will be obvious in the art that changes and modifications may be made without departing from the teachings of the invention. The matter set forth in the foregoing description and accompanying drawings is offered by way of illustration only and not as a limitation. The actual scope of the invention is intended to be defined in the following claims when viewed in their proper perspective based on the prior art.



Claims:

1. An adapter connectable with an automatic power injector and a cartridge, the cartridge containing contents to be dispensed, said adapter comprising means for agitating the content of the cartridge.
2. An adapter as claimed in claim 1, wherein said adapter comprises an adapter body receivable by a cartridge-receiving-unit of the power injector.
3. An adapter as claimed in claim 1 or 2 comprising:
 - i) an elongate adapter body receivable by the power injector;
 - ii) a cartridge retainer for retaining the cartridge; and
 - iii) a cartridge driver for agitating the contents of the cartridge.
4. An adapter according to claim 3, wherein said cartridge retainer further comprises an annular cartridge ring defining an insertion aperture, said cartridge ring further comprising cartridge retaining means extending about said insertion aperture for engaging and retaining the cartridge, said cartridge retaining means engage and retain the cartridge.
5. An adapter according to claim 4, wherein said cartridge retaining means engages at least one flange transversely projecting from the cartridge.
6. An adapter according to claim 4 or 5, wherein said cartridge driver further comprises a motor and drive means for urging said cartridge ring to rotate about said insertion aperture.
7. An adapter according to claim 6, wherein said drive means further comprises a drive belt engaging a moving portion of said motor and said cartridge ring.
8. An adapter according to any of claims 4 to 7, wherein said cartridge driver causes said cartridge ring to reciprocally rotate about said insertion aperture.
9. An adapter as claimed in any of claims 1 to 8 further comprising a portion being sized and shaped so as to be recognizable by a size-reading unit of the power injector.
10. An adapter according to any of claims 3 to 9, further comprising a cartridge holding arm, wherein said cartridge retainer is positioned towards a free end of said cartridge holding arm.

11. An adapter according to any of claims 3 to 10, further comprising an elongate guide piston, wherein said adapter body defines a guide piston opening and an elongate guide piston passageway in fluid communication with said guide piston opening for slidably receiving said guide piston moving between a first and a second position.
12. An adapter according to claim 11, further comprising an extension arm supported by said guide piston, said extension arm including a free end in movable spaced registry with said cartridge retainer.
13. An adapter according to claim 12, further comprising a drive rod supported by said extension arm, said drive rod engaging a dispensing member of the cartridge so as to cause the contents to be dispensed as said drive rod is moved relative to said cartridge retainer.
14. An adapter according to claim 13, wherein said drive rod is rotateably mounted to said extension arm so as to enable said drive rod to rotate with the cartridge.
15. An adapter as claimed in any of claims 3 to 14 wherein said adapter body further comprises an elongate cylindrically shaped housing portion receivable in the power injector.
16. An adapter according to any of claims 3 to 15, wherein said cartridge retainer is offset from said adapter body.
17. An adapter of any of claims 1 to 16 adapted to connect to a cartridge such that the adapter body and the cartridge are positioned substantially in parallel.
18. An adapter of any of claims 1-16 wherein the cartridge mounts to one end of said adapter body.
19. Apparatus for administration of a liquid composition comprising an automatic power injector, a cartridge and an adapter as claimed in any of claims 1-18.
20. Method of administration of a liquid using an apparatus as claimed in claim 19.
21. Method as claimed in claim 20, wherein said administration is by infusion.

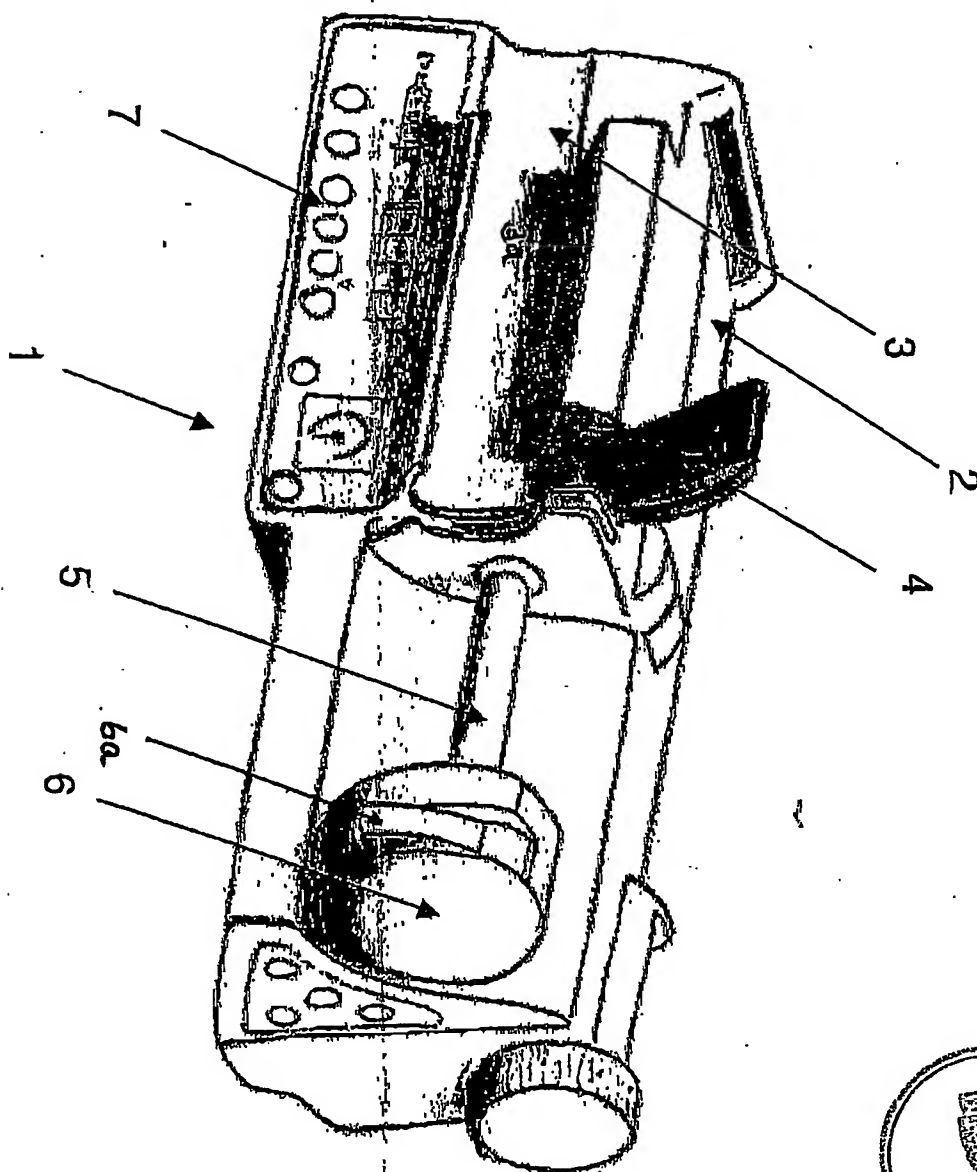


Abstract

Administration by injection or infusion to patients of liquid compositions for diagnostic or therapeutic purposes is provided by a cartridge adapter connectable with an automatic power injector and an elongate cartridge containing contents to be dispensed. The cartridge adaptor includes an elongate adaptor body receivable by the power injector, a cartridge retainer for retaining the cartridge, and a cartridge driver for agitating the contents of the cartridge. More particularly the invention relates to an adapter connectable with a power injector and methods for delivery of a composition using such adapter. By connecting an adapter according to the invention to a cartridge and a power injector, rotation of the cartridge is achieved and homogeneity of the composition is preserved. Particularly, the composition is an ultrasound contrast agent comprising an aqueous dispersion of gas-filled microbubbles or of particulate matter.



Figure 1.



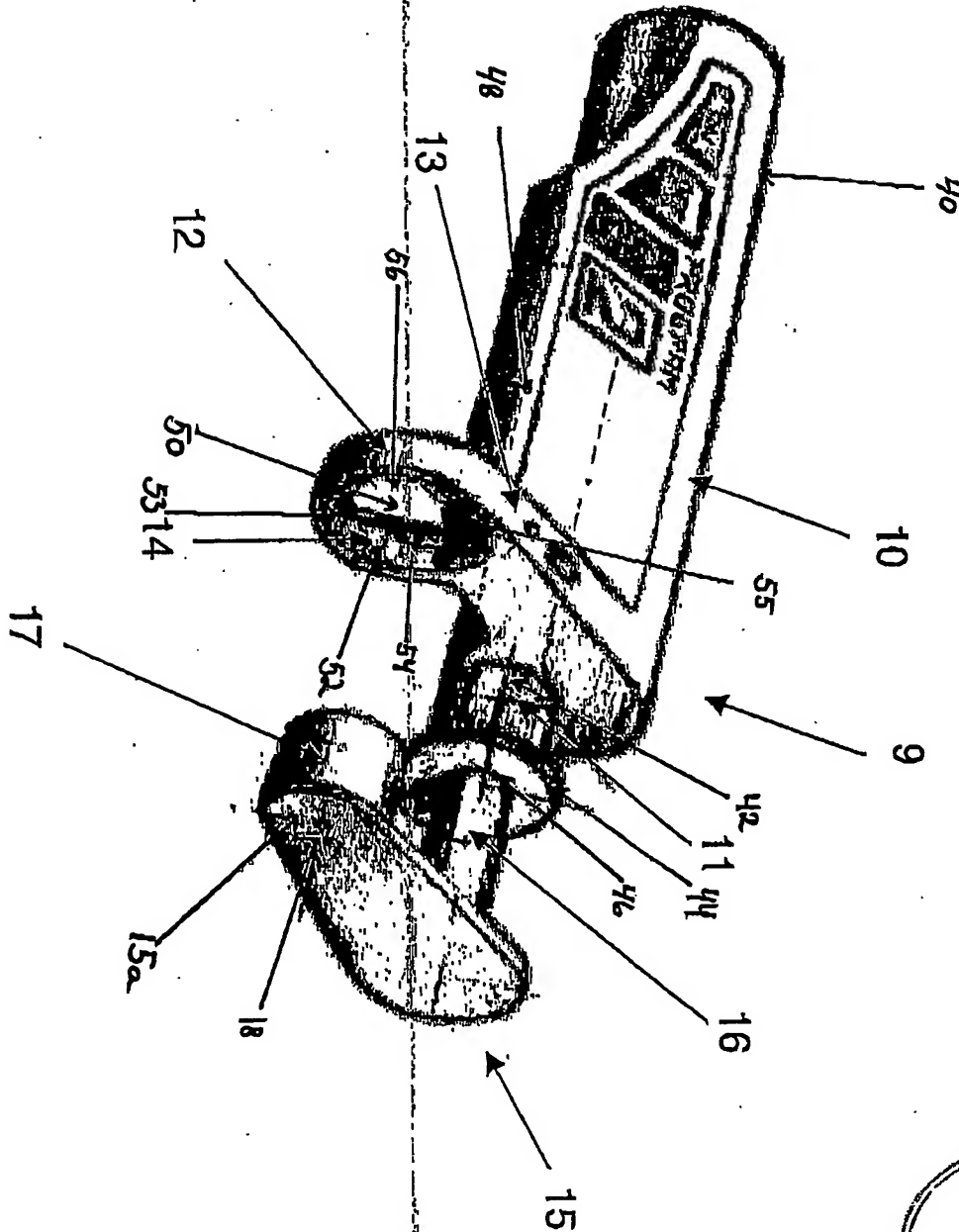
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Figure 2a.



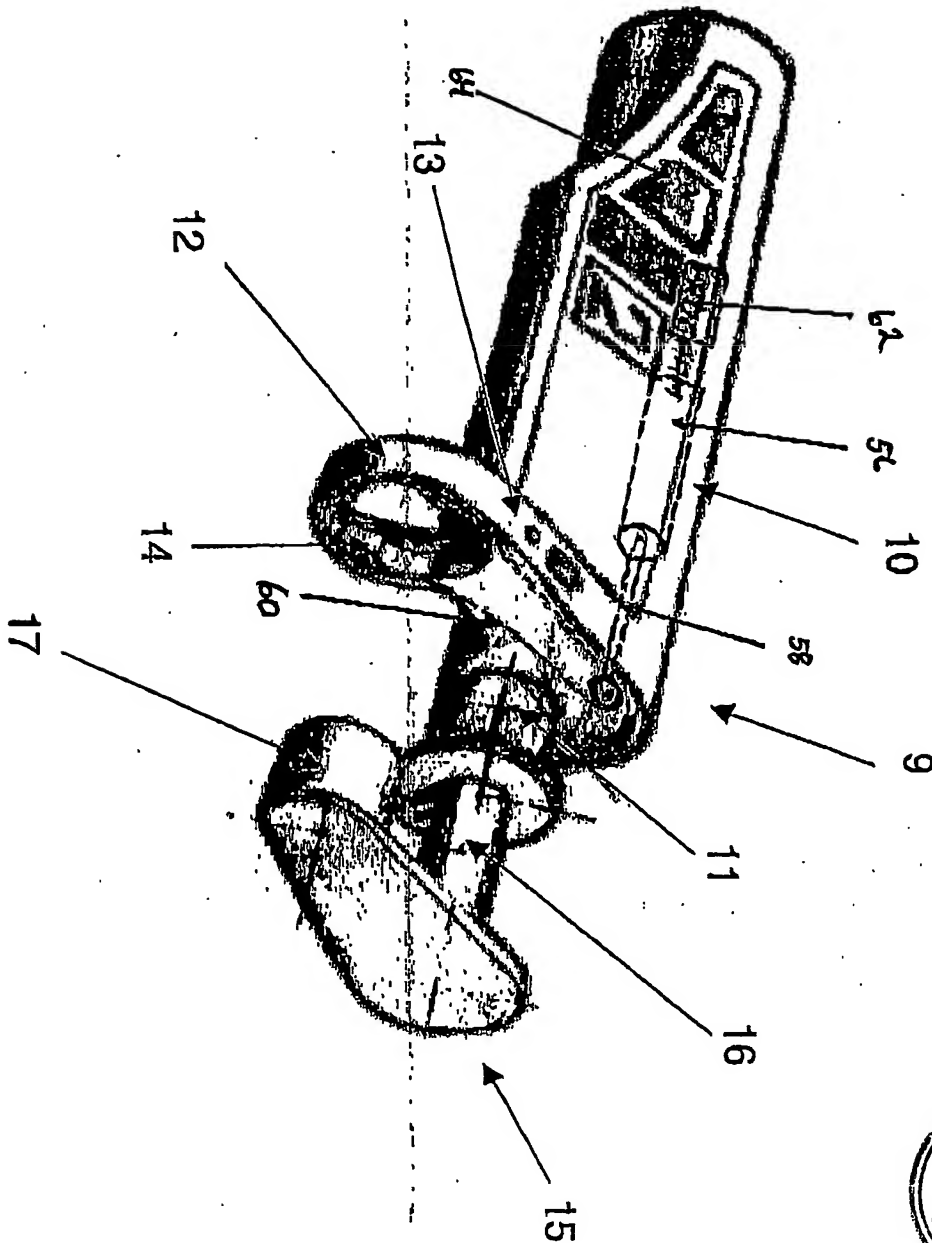
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Figure 2b.

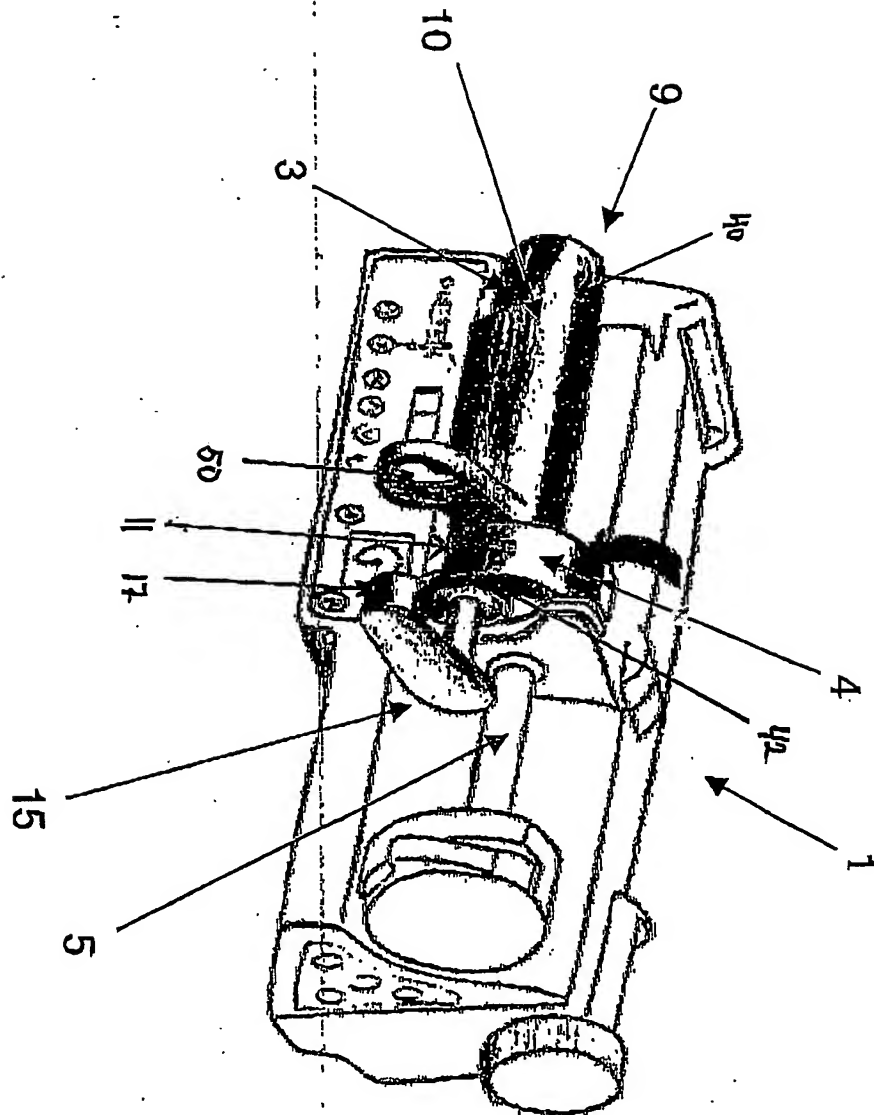


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Figure 3.



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Figure 4.

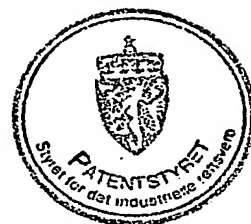
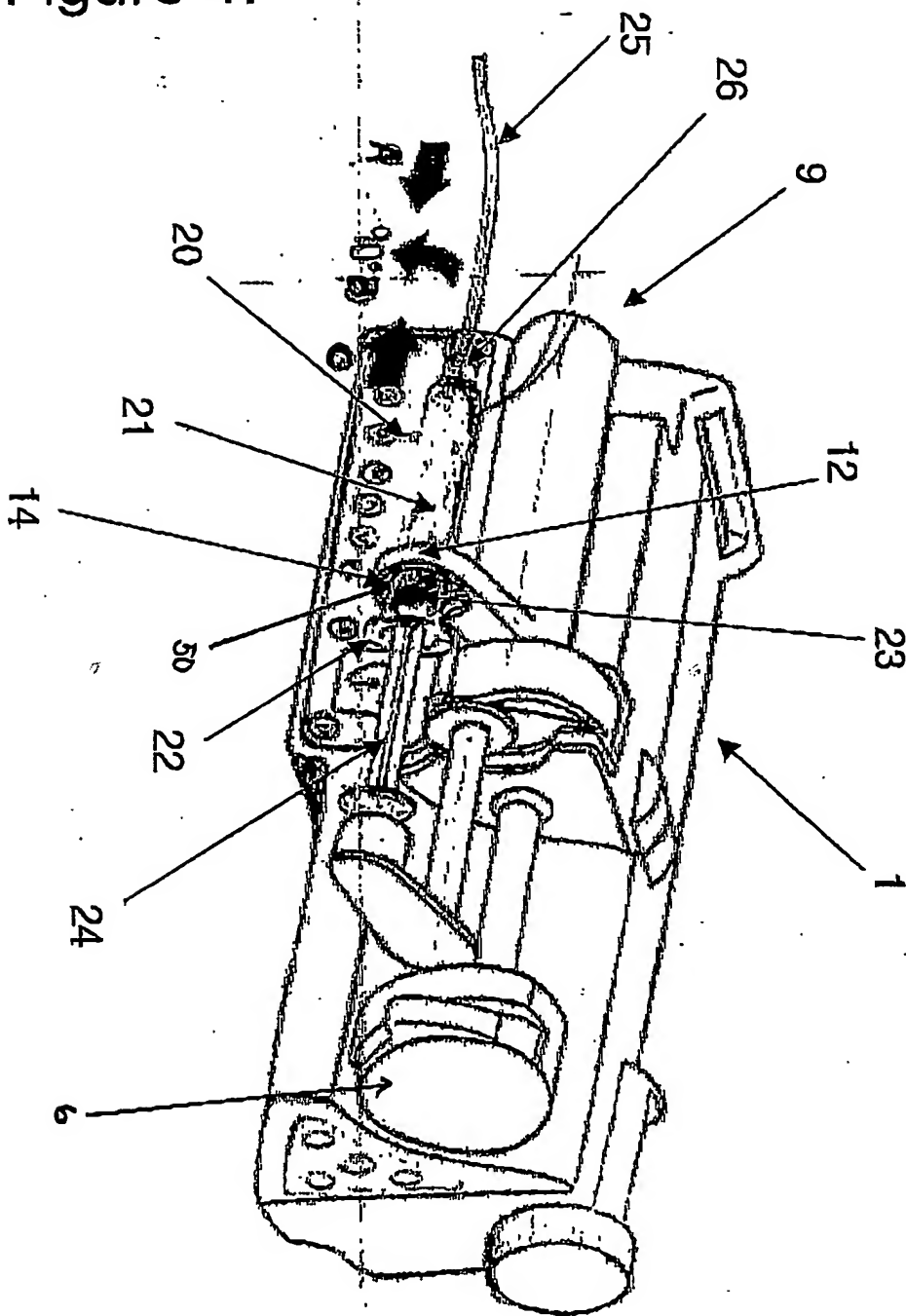
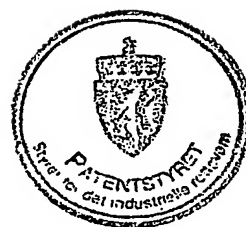
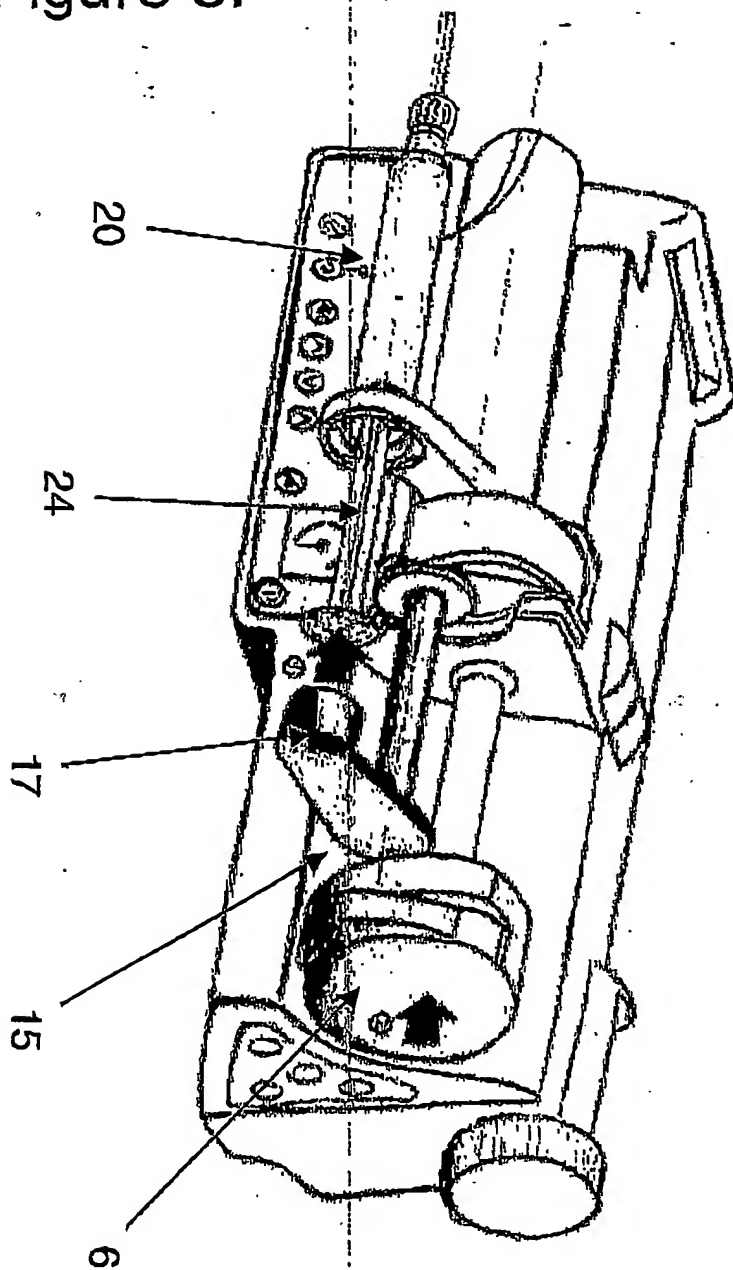


Figure 5.



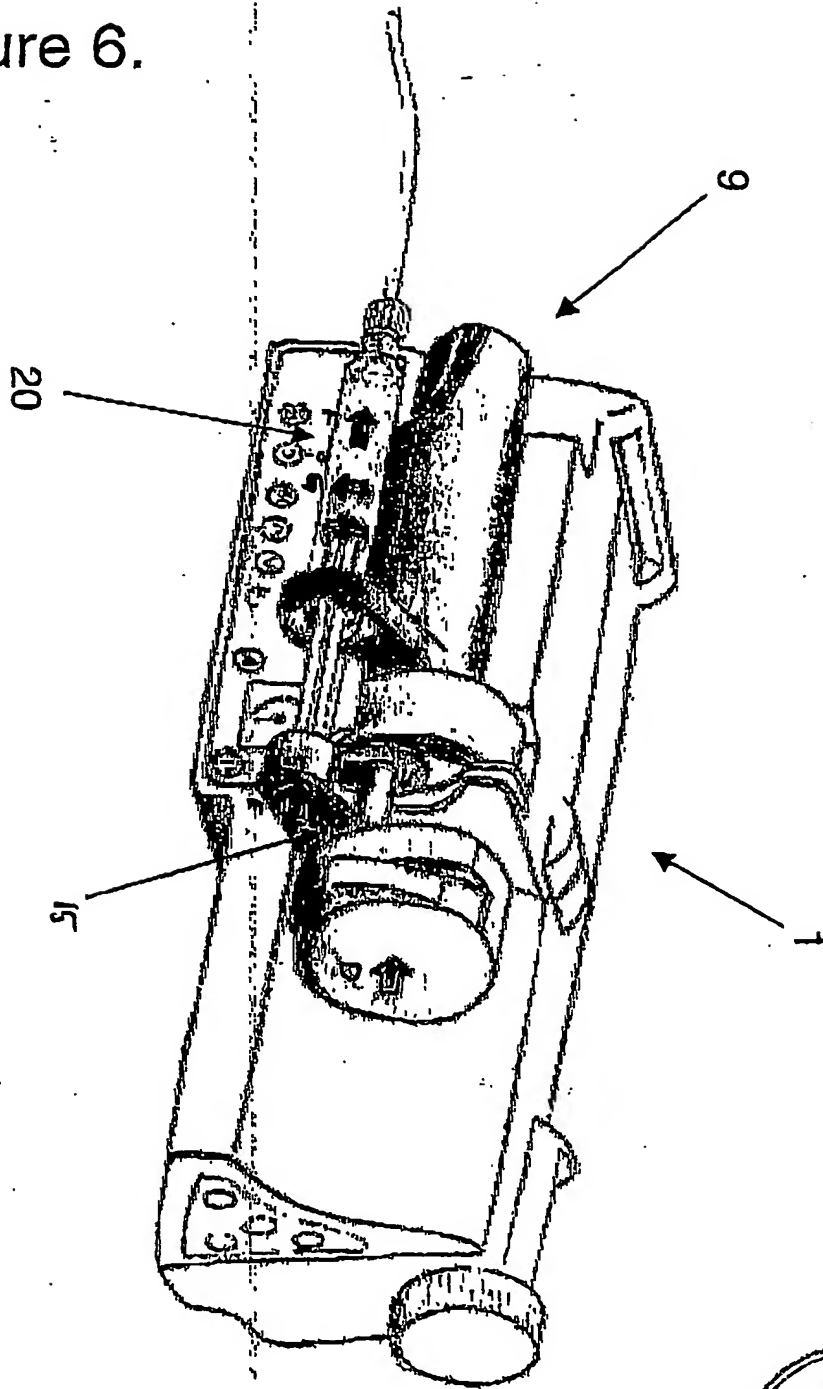
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Figure 6.

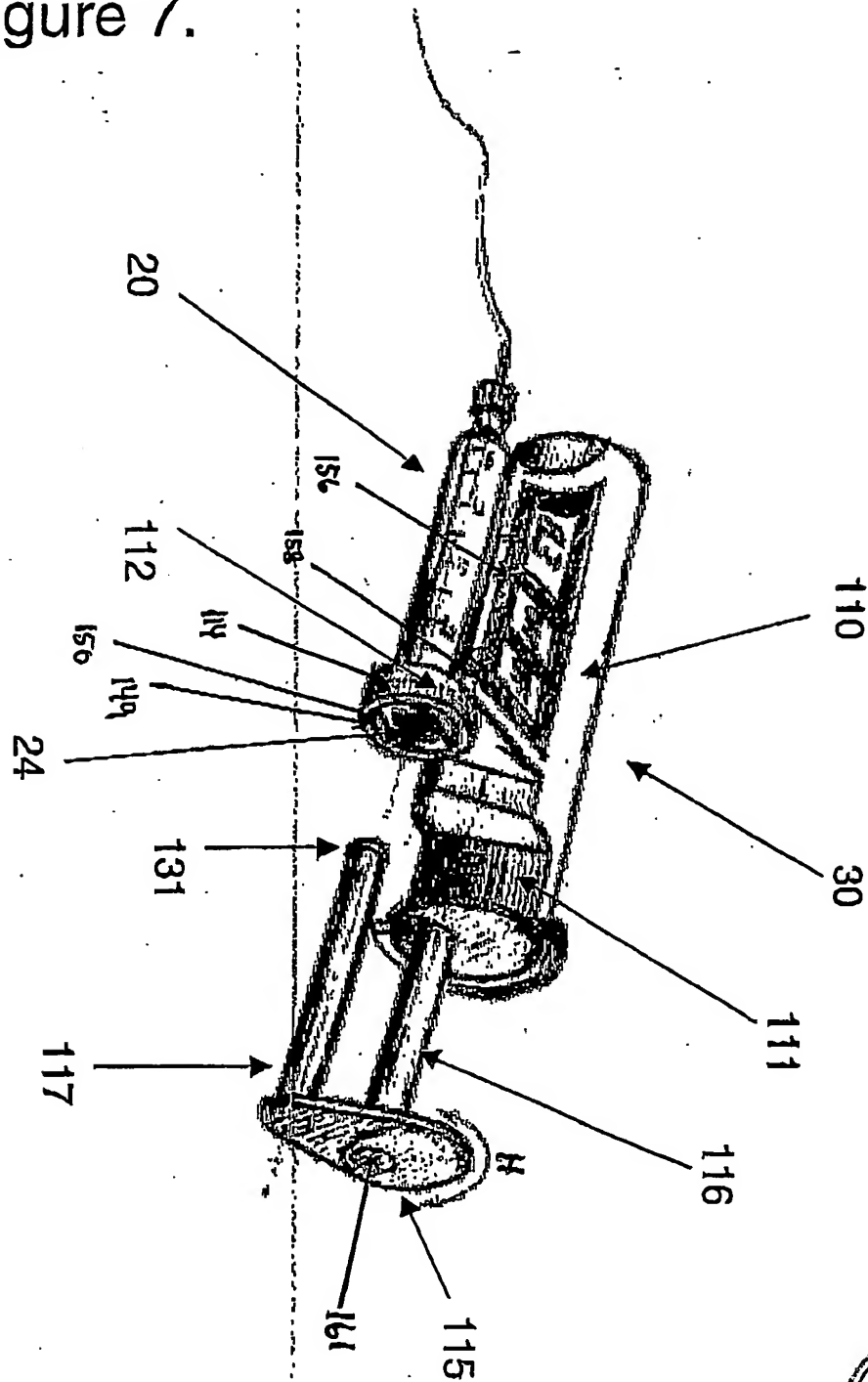


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Figure 7.



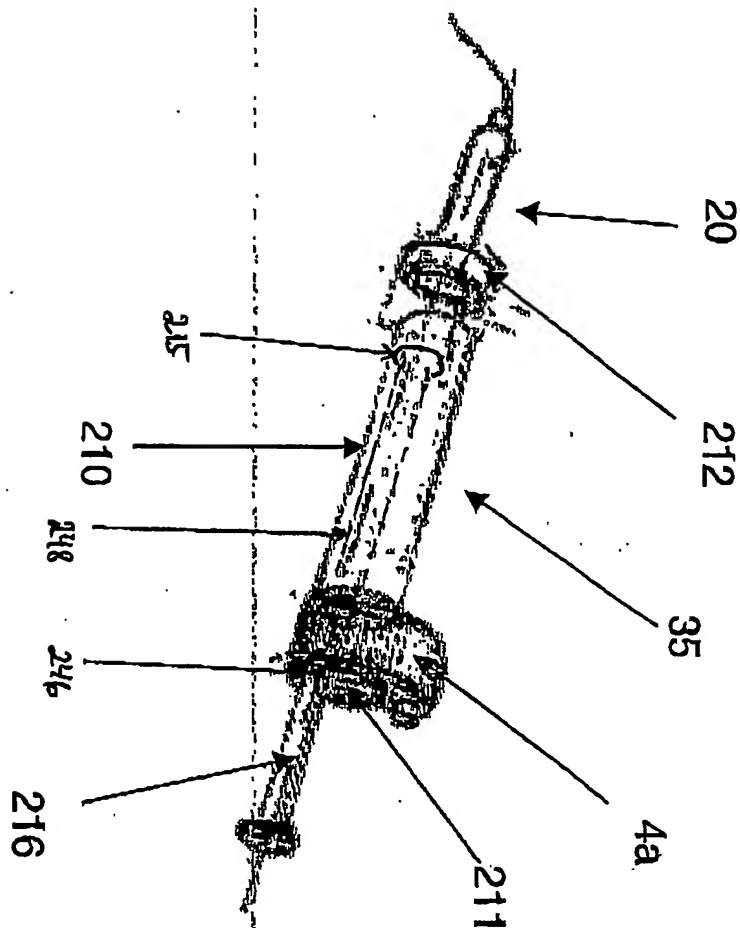
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Figure 8.



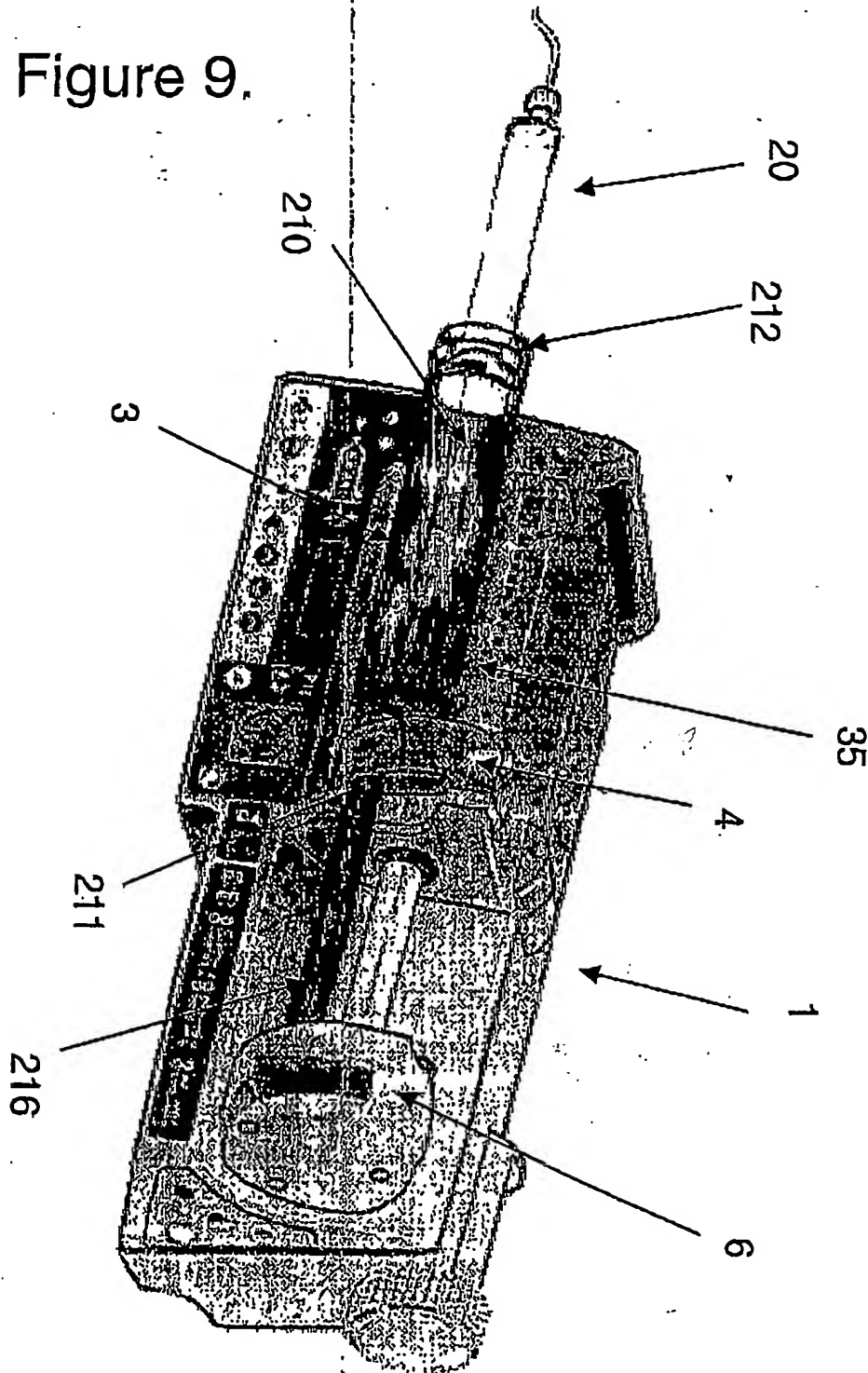
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Figure 9.



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